End-tidal CO_2 pressure: an important parameter for a correct interpretation of changes in cerebral hemodynamics and oxygenation measured with functional near infrared spectrophotometry (fNIRS)

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The aim of the present study was to investigate the effects of different speech tasks (recitation of prose (PR), alliteration (AR) and hexameter (HR) verses) and a control task (mental arithmetic (MA) with voicing of the result) on end-tidal CO_2 (ET-CO_2), cerebral hemodynamics; i.e. total hemoglobin (tHb) and tissue oxygen saturation (StO_2). tHb and StO_2 were measured with a frequency domain near infrared spectrophotometer (ISS Inc., USA) and ET-CO_2 with a gas analyzer (Nellcor N1000). Measurements were performed in 24 adult volunteers (11 female, 13 male; age range 22 to 64 years) during task performance in a randomized order on 4 different days to avoid potential carry over effects. Statistical analysis was applied to test differences between baseline, 2 recitation and 5 recovery periods. The two brain hemispheres and 4 tasks were tested separately. Data analysis revealed that during the recitation tasks (PR, AR and HR) StO_2 decreased statistically significant ($p < 0.05$) during PR and AR in the right prefrontal cortex (PFC) and during AR and HR in the left PFC. tHb showed a significant decrease during HR in the right PFC and during PR, AR and HR in the left PFC. During the MA task, StO_2 increased significantly. A significant decrease in ET-CO_2 was found during all 4 tasks with the smallest decrease during the MA task. In conclusion, we hypothesize that the observed changes in tHb and StO_2 are mainly caused by an altered breathing during the tasks that led a lowering of the CO_2 content in the blood provoked a cerebral CO_2 reaction, i.e. a vasoconstriction of blood vessels due to decreased CO_2 pressure and thereby decrease in cerebral blood volume. Therefore, breathing changes should be monitored during brain studies involving speech when using functional near infrared spectroscopy (fNIRS) to ensure a correct interpretation of changes in hemodynamics and oxygenation.